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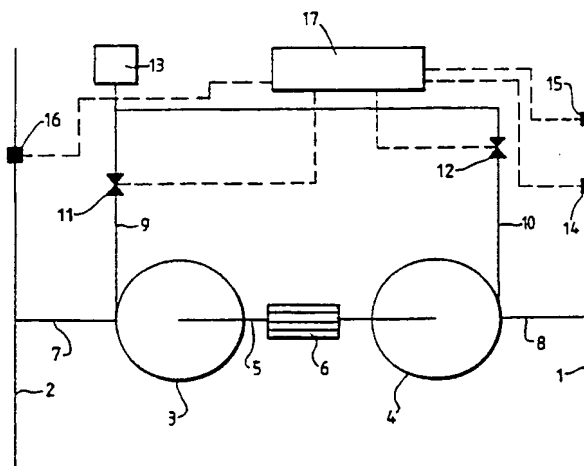
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54 An improved ventilation system.

57 A fluidic ventilation control system comprises a pair of vortex valves (3, 4) connected axial port to axial port in a passageway (7, 8) which can connect a main tunnel (1) with a service tunnel (2). The tangential ports of the vortex valves communicate with pressure gas supply (13), with valves (11, 12) to control the supply of pressure gas to the vortex valves. The valves (11, 12) are responsive to signals generated by sensors, such as pressure and heat detectors, in the tunnels to control the supply of pressure gas to thereby regulate the flow in the passageway in response to changes in conditions in the tunnels.



EP 0 392 713 A1

## An Improved Ventilation System

The present invention concerns a fluidic ventilation control system.

The invention seeks to provide a ventilation control system which does not utilise conventional valves but rather relies upon fluidic devices known as vortex valves which do not have moving parts and seals which suffer corrosion and wear during use. A vortex valve comprises a vortex chamber having axial, radial and tangential flow ports.

According to one aspect of the present invention a fluidic ventilation control system comprises a pair of vortex valves as herein defined, the axial ports of the valves being connected together to form a part of a passageway, the radial ports being in communication with the passageway, the tangential ports being connected to a pressure fluid supply and selectively operable means to regulate the supply of pressure fluid to the tangential ports and to direct the pressure fluid to one or other of the vortex valves to thereby regulate the extent and direction of flow in the passageway.

According to another aspect of the present invention a fluidic ventilation control system for a tunnel comprises two vortex valves each having a vortex chamber with radial, axial and tangential ports, the axial ports of the vortex valves being interconnected, the radial port of one of the vortex valves being in direct communication with the tunnel and the tangential ports of the two vortex valves being in communication with pressure gas supply means controlled by valves responsive to signals generated in the tunnel.

The vortex valves can be arranged between a main tunnel for vehicular traffic and a separate service tunnel with the radial port of the other vortex valve being in direct communication with the service tunnel.

According to yet another aspect of the present invention a method of regulating flow in a passageway comprises including a pair of vortex valves as herein defined in the passageway, interconnecting the axial ports of the valves, connecting a pressure fluid supply to the control ports of the valves and selectively regulating the supply of pressure fluid to one or other of the vortex valves to thereby control and regulate the extent and direction of flow in the passageway.

The invention will be described, by way of example, with reference to the accompanying drawing which is a diagrammatic representation of a control system for tunnel ventilation.

In the drawing, a main or running tunnel for road or rail traffic is denoted by reference numeral 1 and a service tunnel used for ventilating and providing services to the tunnel 1 is represented by

the reference numeral 2. First and second vortex valves 3 and 4 respectively are connected together and to the two tunnels. The vortex valves each has a vortex chamber with axial, radial and tangential ports and in the present arrangement the two vortex valves are connected axial port to axial port as denoted by reference numeral 5. A flow straightener 6 can, if required, be included in the line 5. Flow exiting from the vortex valves can have a spiral motion and the flow straightener serves to eliminate such motion. The radial port of the first vortex valve 3 is connected to the service tunnel 2 by line 7 and likewise the radial port of the second vortex valve 4 is connected to the main or running tunnel 1 by line 8. The two vortex valves are thus included in a passageway between the tunnels. Pressurised gas from a separate supply 13 is supplied to the tangential ports of the two vortex valves along control lines 9 and 10 respectively. A control valve 11 is in line 9 and a control valve 12 is in line 10. Sensors or detectors, coupled to a control/interface unit 17 for the valves 11 and 12, are located in the two tunnels 1 and 2. In the present example a pressure sensor 14 and a heat or fire sensor 15 are arranged in the main or running tunnel 1 and a heat or fire sensor 16 is arranged in the service tunnel 2.

In use, and in the absence of flows in the control lines 9 and 10, there is a through unimpeded flow passage through the vortex valves between the two tunnels. Under normal operation, the vortex valve 3 has two functions. First, it serves to ventilate the main tunnel 1 by controlling the amount of fresh air flowing into the tunnel 1 from the service tunnel 2. This is achieved by suitably sizing the vortex valve components and applying an appropriate flow along the control line 9 to the tangential port or ports of the vortex valve 3. Second the vortex valve 3 serves to minimise flow perturbations in the main tunnel 1 by varying the tangential control flow 9 in accordance with a signal from the pressure sensor 14 in the tunnel 1 controlling operation of the valve 11. Under normal operating conditions the valve 12 is closed and consequently no control flow will be applied along the line 10 to the tangential port or ports of the vortex valve 4. As a result fresh air from the service tunnel 2 to ventilate the main tunnel flows unhindered through the vortex amplifier 4.

In the event of fire in the service tunnel 2, a signal from the sensor 16 is applied to the control/interface unit 17 to open fully the valve 11 and permit maximum control flow in the line 9 to the tangential port or ports of the vortex valve 3. The signal from the sensor 16 overrides any other

signal being applied to the valve 11. The strong vortex established in the vortex valve 3 as a result of the control flow is such as to stop the spread of fire or smoke from the service tunnel 2 to the main tunnel 1.

Larger than normal pressure fluctuations are likely to occur when a high speed vehicle or train passes through the tunnel 1. A high positive pressure in front of the vehicle or train can cause an unwanted reverse flow from the tunnel 1 to the service tunnel 2. Such a reverse flow can be stopped by applying compressed air from supply 13 along the line 10 to the tangential port or ports of the vortex valve 4. In this state, the vortex valve 4 functions in the manner of a non-return valve. The operation can be arranged to function whenever the pressure signal, as determined by the sensor 14, exceeds a certain predetermined value to fully open valve 12. Simultaneously, the valve 11 can be closed in response to the signal from the sensor 14 to provide the control flow to the vortex valve 4 with a low resistance path to the service tunnel 2. The amount of control flow passing to the service tunnel 2 will be smaller than the flow resulting from an unimpeded large pressure pulse.

In the event of fire in the main tunnel 1, the sensor 15 provides a signal to fully open the valve 12 and at the same time to close the valve 11. As a result, a strong vortex is established in the vortex valve 4 to prevent the passage of smoke or fire from the main tunnel 1 to the service tunnel 2 and the vortex amplifier 3 provides a low resistance escape path from the control flow entering the vortex valve 4.

A plurality of pairs of vortex amplifiers, each pair being arranged as depicted in the drawings, can be located at spaced intervals along and between the tunnels.

The present invention is not limited to use with tunnels. A pair of vortex valves interconnected as shown and described with reference to the illustrated embodiment can be used to control the extent and direction of flow in a passageway or the like. The direction of flow in the passageway is determined by the appropriate vortex valve and the extent or amount of the flow is regulated by the amount or degree of control flow applied to the tangential port or ports of the vortex valve.

## Claims

1. A fluidic ventilation control system which comprises a pair of vortex valves (3, 4) as herein defined, the axial ports of the valves being connected together to form a part (5) of a passageway (7, 8) the radial ports being in communication with the passageway, the tangential ports being con-

nected to a pressure fluid supply (13) and selectively operable means (11, 12) to regulate the supply of pressure fluid to the tangential ports and to direct the pressure fluid to one or other of the vortex valves (3, 4) to thereby regulate the extent and direction of flow in the passageway.

2. A system according to claim 1 characterised in that the passageway provides communication between a main tunnel (1) and a service tunnel (2) for the main tunnel.

3. A system according to claim 2 characterised in that the selectively operable means comprises control valves (11, 12) in control flow lines (9, 10) to the vortex valves.

4. A system according to claim 3 characterised by sensors (14, 15, 16) sensitive to conditions in the main and service tunnels for actuating the control valves (11, 12).

5. A system according to claim 4 characterised in that the sensors include pressure (14) and heat (15, 16) detectors.

6. A fluidic ventilation control system for a tunnel comprising two vortex valves (3, 4) each having a vortex chamber with radial, axial and tangential ports, the axial ports of the vortex valves being interconnected, the radial port of one of the vortex valves (4) being in direct communication with the tunnel (1) and the tangential ports of the two vortex valves being in communication with pressure gas supply means (13) controlled by valves (11, 12) responsive to signals generated in the tunnel (1).

7. A fluidic ventilation control system according to claim 6 characterised in that the radial port of the other vortex valve (3) is connected to a service tunnel (2).

8. A method of regulating flow in a passageway characterised by including a pair of vortex valves (3, 4) as herein defined in the passageway (7, 8), interconnecting the axial ports of the vortex valves, connecting a pressure fluid supply (13) to the control ports of the vortex valves and selectively regulating the supply of pressure fluid to one or other of the vortex valves (3, 4) to thereby control and regulate the extent and direction of flow in the passageway (7, 8).

9. A method according to claim 8 characterised by connecting the passageway (7, 8) between a main tunnel (1) and a service tunnel (2).

10. A method according to claim 9 characterised by utilising signals from the tunnels (1, 2) to control the supply of pressure fluid to the vortex valves (3, 4).

